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Gold Vapor Laser Versus Tunable Argon-Dye Laser for Endobronchial Photodynamic Therapy

James. S. McCaughan, Jr., MD, Rostislav D. Barabash, MD, Dale R. Hatch, LEOT, AS, and Deborah C. McMahon, RN

Grant Laser Center and Laser Medical Research Foundation, Columbus, Ohio, 43215

Background and Objective: **To compare the effectiveness of a gold vapor pulsed laser versus an argon dye continuous wave laser system in decreasing the amount of obstruction caused by endobronchial tumors when they are treated with photodynamic therapy (PDT).**
Study Design/Materials and Methods: **The percentage of endobronchial obstruction from tumors before and at the end of PDT, and before and at the end of toilet bronchoscopy of 96 sites treated with light generated by a Spectra Physics tunable argon dye system were compared to those of 17 sites treated with light generated by a gold vapor laser. All patients were injected intravenously with 60 mg of dihematoporphyrin ethers per square meter of body surface. All treatments were done with a power density of 500 mW/CF and a light dose of 400 J/CF delivered from cylinder diffusing fibers.**
Results: **Paired Student's *t*-tests and Wilcoxon signed ranks tests showed significant decreases in the percentage of endobronchial obstruction due to PDT regardless of the laser used. Unpaired Student's *t*-tests and Mann-Whitney U statistical comparisons showed no significant difference between the two lasers in the percentage decrease at PDT, percentage increase from exudate seen at toilet bronchoscopy, nor the percentage decrease at the end of the toilet bronchoscopy from that before PDT.**
Conclusion: **We found no statistically significant difference in the decrease in the amount of endobronchial tumor obstruction obtained when the light for treatment was generated by a pulsed gold vapor or a continuous wave argon dye laser system.**

Key words: gold vapor, pulsed, continuous wave, endobronchial, photodynamic therapy

INTRODUCTION

Because photodynamic therapy of tumors requires a suitable wavelength light source to activate the photosensitizer, much effort has been spent in designing new light sources that will be more stable, mobile, and smaller than the currently used continuous wave argon tunable dye laser system. Some of these are pulsed laser systems and there has been a question as to the effectiveness of the continuous wave system compared to a pulsed system. Most of the research on this question has been in the laboratory with a few sporadic reports of the clinical use of a pulsed system. We report here a controlled comparison of the effectiveness of a gold vapor laser pulsed system with an argon dye laser system in decreasing the amount of endobronchial obstruction caused by clinical endobronchial tumors.

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Address reprint requests to James S. McCaughan, Jr., MD, Grant Laser Center and Laser Medical Research Foundation, Columbus, OH 43215.

TABLE 1. % Endobronchial Obstruction for Argon-Dye vs. Gold

		Before PDT	End PDT	At toilet	End toilet
Argon-dye (n = 96)	% Obstruction	48	29	78	19
Gold vapor (n = 17)	% Obstruction	42	32	68	20
	Difference % obstruction	6	3	10	1
P values difference	Student's *t*-test	0.5142	0.5821	0.2264	0.8797
(95% Confidence)	Mann-Whitney	0.7972	0.2863	0.6101	0.4173

TABLE 2. % Endobronchial Obstruction for Argon-Dye vs Gold

				P Values difference (95%)	
	Before PDT	End toilet	Decrease	Student's *t*-test	Wilcoxon signed rank
Argon-dye (n = 96)	48	19	29	<.0001	<.0001
Gold vapor (n = 17)	42	20	22	0.0424	0.0268

METHODS

Seventeen consecutive endobronchial tumor sites were treated with PDT using a gold vapor laser (Metal Laser Model MM-2400, CJ Laser Corp., Dayton, OH) to generate a pulsed treatment light of 627.8 nm. This delivers 2 watts average power at a 15 kHz repetition rate with 80–90% coupling with existing 400 micron fibers. An optical feedback ensures output stability ±5%. It is air cooled and is easily movable into the operating suite.

The percentage of endobronchial obstruction from tumors was estimated before and at the end of PDT, and before and at the end of toilet bronchoscopies performed 1 day after PDT from the known diameters of the bronchoscope and biopsy forceps and the adjacent normal bronchus. These estimates were checked with endobronchial photographs.

All patients were injected intravenously with 60 mg of dihematoporphyrin ethers (Photofrin, Quadra Logic Technologies, Vancouver, B.C., Canada) per square meter of body surface. All treatments were done with a power density of 500 mW/centimeter of cylindrical diffuser tip (CF) and a light dose of 400 J/CF delivered from cylinder fibers with 2.5 cm long diffusing tips (Quadra Logic Technologies, Vancouver, B.C., Canada).

The results were compared to those obtained from the previous 96 endobronchial tumor sites treated with the same parameters but with the light (630 nm) generated by a Spectra Physics (Mt. View, CA) 20-w argon (model 171) tunable dye (model 375) laser system with a single plate birefringent filter. Kiton red (Exciton, Dayton, OH) was used for the lasing medium.

Essentially the only difference in the technique of the treatments of the two series was the laser used.

This information was evaluated using the computer statistic program Statview (Abacus Concepts, Berkeley, CA, 1992).

Student's *t*-tests and Mann-Whitney U tests were used for unpaired comparisons using 95% confidence levels. Comparisons were made between the two series for the percent obstruction before and at the end of the PDT and toilet bronchoscopies.

Similar comparisons were made for the percent decrease of obstruction at PDT; the percent increase from exudate and reaction seen at toilet bronchoscopy from the percent obstruction at the end of PDT; and the percent decrease of obstruction at the end of toilet bronchoscopy from that at the beginning of PDT.

For each series the decrease in the percent obstruction by PDT at the end of the toilet bronchoscopy from that before PDT was evaluated using paired Student's *t*-tests and Wilcoxon signed rank comparisons.

RESULTS

The mean percent endobronchial obstruction before and at the end of PDT and before and at the end of the toilet bronchoscopy for each series treated with the different lasers are listed in Table 1. Unpaired Student's *t*-tests and Mann-Whitney U comparisons (95% confidence levels) showed no significant difference in the percent obstruction at each evaluation between the two series for any of the observations. There was no significant difference in the decrease of obstruction at PDT, the increase seen at toilet bronchoscopy, or the de-

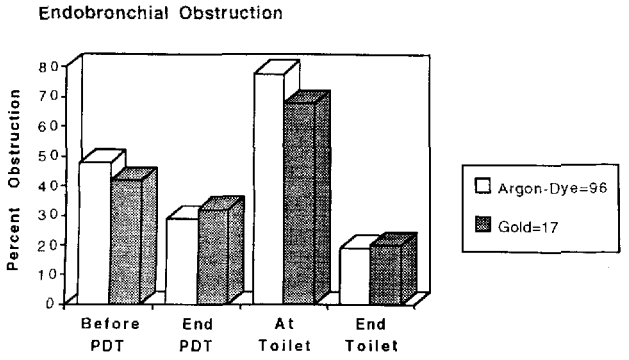

Fig. 1. The average percent obstruction observed at bronchoscopies.

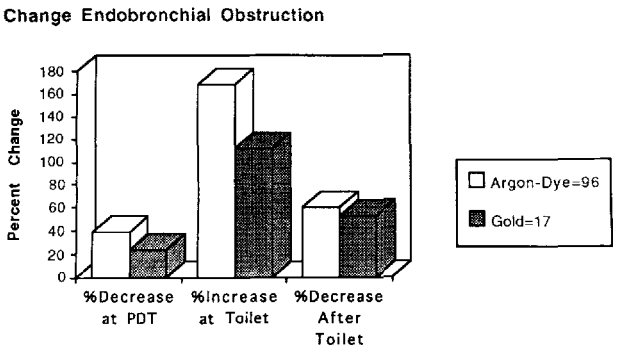

Fig. 2. The percent decrease of endobronchial obstruction at the end of the toilet bronchoscopy from that before PDT.

crease after toilet from that before PDT, between the two lasers.

The decrease in the percent obstruction by PDT was statistically significant (95% confidence) for either laser using paired Student's *t*-tests and Wilcoxon signed rank comparisons (Table 2).

Thus, we found both lasers were effective in reducing the amount of endobronchial obstruction with PDT and there was no significant difference in the effects caused by the two lasers.

DISCUSSION

In a previous study [1] we compared the effect of different doses of the photosensitizer DHE on the percent decrease of obstruction by endobronchial tumors produced by PDT on the basis of mg/kg of body weight versus mg/m^2 of body surface. We found statistically significant differences in the effect of different mg/m^2 when there was no difference when compared on the basis of mg/kg of body weight. We think DHE injected on the basis of mg/m^2 provides a better parameter for effectiveness than mg/kg and we now use 60 mg/m^2 (a mean of 1.4 mg/kg) of DHE for treating endobronchial tumors.

Most PDT clinical treatments in the past have been done with a continuous wave argon dye laser system. To find a "more user friendly" light source, investigators have used pulsed systems such as the KTP/532 double frequency YAG laser to pump the dye laser. Ferrario et al. [2] found no difference in the photodynamic results using this laser system in the laboratory on Chinese hamster fibroblasts, photobleaching of hematoporphyrin ethers in aqueous solution, or animal mammary tumors when compared to a continuous wave laser system.

Cowled et al. [3] found no difference in the photodynamic effects of a pulsed laser versus a continuous wave laser on tissue cultures or mouse tumors.

Ben-Hur et al. [4] claimed a continuous wave was better to decrease the colony forming ability of Chinese hamster fibroblast cells after photoxicity of treatment. However, their pulsed laser had a repetition rate of 4.5 kHz. The pulsed gold vapor laser we used had a repetition rate of 15 kHz.

Hisazumi et al. [5] reported a gold vapor laser at 7 to 10 kHz required significantly less time of irradiation to produce complete remissions in KK-47 tumors when compared to an argon dye laser system.

Panjehpour et al. [6] reported no histologic or gross difference in the PDT effect on normal canine esophageal with DHE when they compared an argon dye pumped laser system to a KTP/532 double frequency pulsed dye YAG system.

We found the gold vapor laser easier to use and the output extremely stable throughout the entire treatment cycle. A drawback was the length of time required for the warm-up. However this has been corrected by programming the system so it will start automatically at a preset time. Since the laser system is air cooled it can be transported from one area to another and wheeled into the operating suite.

In conclusion, we found no statistically significant difference in the decrease in the amount of endobronchial tumor obstruction obtained in the clinical treatment of endobronchial tumors when the light for treatment was generated by a

pulsed gold vapor (15 kHz, 627.8 nm) or a continuous wave argon dye (630 nm) laser system.

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